Northrop Grumman TR202 LOX/GH2 Deep Throttling Engine Project Status

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Introduction

NASA's Propulsion and Cryogenic Advanced Development (PCAD) project is currently developing enabling propulsion technologies in support of the Exploration Initiative, with a particular focus on the needs of the Altair Project. To meet Altair requirements, several technical challenges need to be overcome, one of which is the ability for the lunar descent engine(s) to operate over a deep throttle range with cryogenic propellants. To address this need, PCAD has enlisted Northrop Grumman Aerospace Systems (NGAS) in a technology development effort associated with the TR202, a LOX/LH2 expander cycle engine driven by independent turbopump assemblies and featuring a variable area pintle injector similar to the injector used on the TR200 Apollo Lunar Module Descent Engine (LMDE). Since the Apollo missions, NGAS has continued to mature deep throttling pintle injector technology. The TR202 program has built hardware and completed two phases of pintle injector testing. The first phase of testing used ablative thrust chambers and demonstrated igniter operation as well as stable performance at various power levels across the designed 10:1 throttle range. The second phase of testing was performed on a calorimeter chamber and demonstrated injector performance at various power levels (75%, 50%, 25%, 10%, and 7.5%) across the throttle range as well as measured chamber heat flux to show that the engine can close an expander cycle design across the throttle range. After these two successful test programs, the program plan is to next demonstrate continuous throttling with an actuator and to move towards integrated engine sea-level test-bed testing.

Program Milestones

The TR202 program began in May 2005 and has completed two key phases. Figure 1 shows the program schedule. Phase one took the engine technology from a TRL 2 to TRL 3 and Phase two took the technology to TRL 4. Phase one identified the key technology drivers for the program. Figure 2 shows those drivers. The rest of the section will describe the key milestones of each phase, how the milestones drove the hot-fire testing, and when the milestones were accomplished.

System Modeling

The initial engine system design used the Rocket Engine Transient Simulation (ROCETS) tool as well as more detailed component tools. The analysis showed that uncertainties in injector performance and chamber heat flux throughout the power range could cause significant changes to the engine design. The test program decreased the uncertainty by characterizing pintle injector performance and chamber heat transfer for the first time using liquid oxygen and gaseous hydrogen.

Using the test results, the conceptual design of the TR202 engine system has been updated in preparation for the next phase of the program. This section will describe that effort. It will also describe how the test data creates a database that allows the engine conceptual design to again be quickly updated once the Altair program releases firm requirements.

Path Forward

This section will describe the path forward for the TR202 program. It will describe continuous throttling testing with an actuator as well as opportunities to move towards integrated engine sea-level test-bed testing.

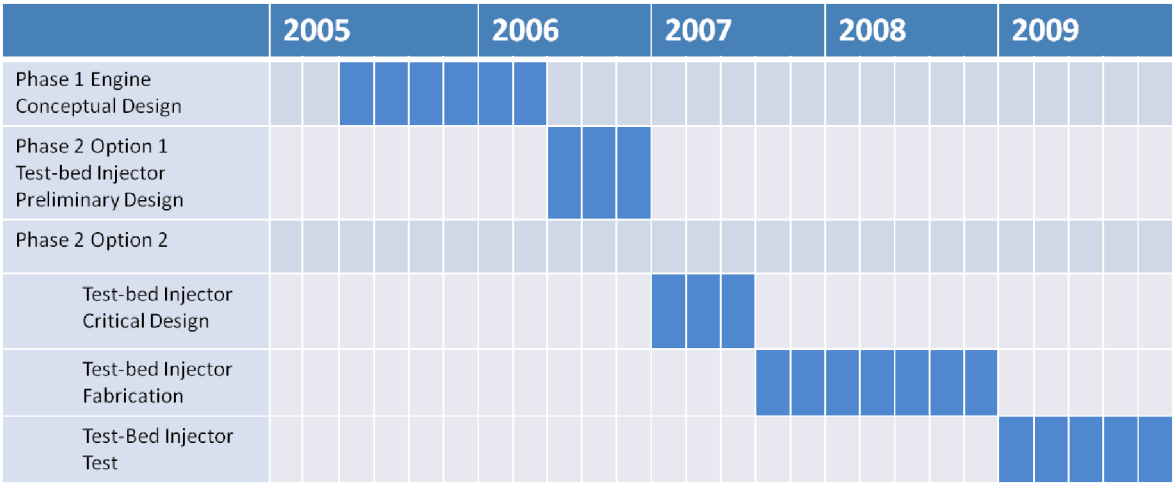


Figure 1. TR202 Program Schedule

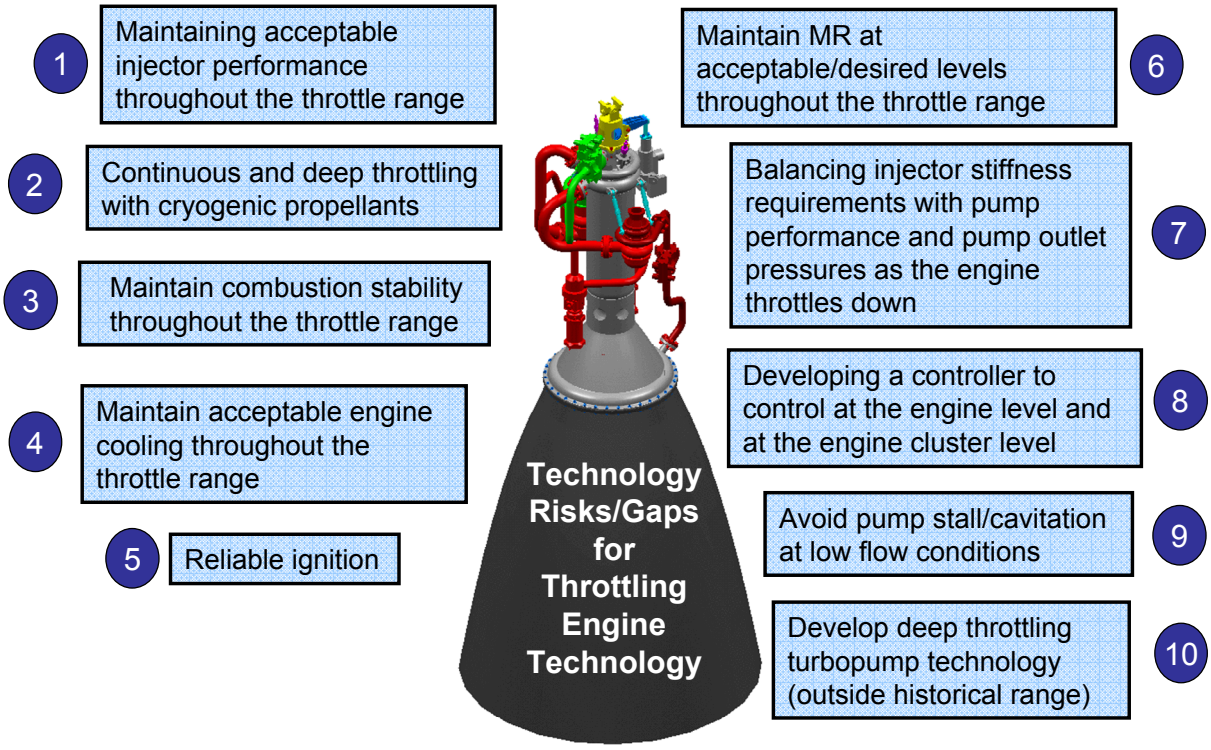


Figure 2. Lunar Lander Descent Engine Technical Challenges